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(54) **INFORMATION PROCESSING APPARATUS AND INFORMATION PROCESSING METHOD**

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G06F 13/00	(2006.01)
G06F 9/50	(2006.01)
G06F 21/51	(2013.01)
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(52) **U.S. Cl.**

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(58) **Field of Classification Search**

CPC G06F 9/5016; G06F 21/51; G06F 21/6209

USPC 719/319

See application file for complete search history.

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(57) **ABSTRACT**

An information processing apparatus executes an application program including an application resource and a runtime. The information processing apparatus includes a memory, and a processor that executes a procedure in the memory. The procedure includes generating a process space in the memory to invoke the application program, loading the runtime into the process space, loading the application resource into the process space into which the runtime is loaded, generating a process of the application program based on the application resource and the runtime which are loaded into the process space, and executing the process of the application program.

20 Claims, 12 Drawing Sheets

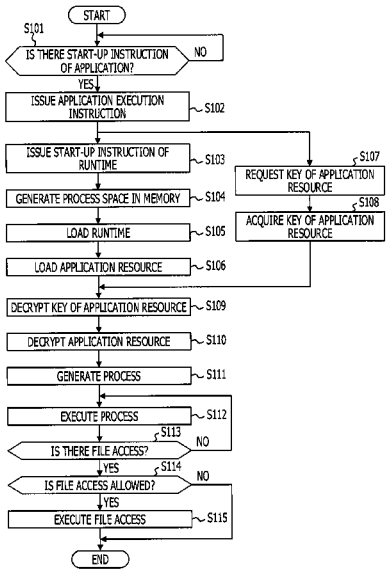


FIG. 1

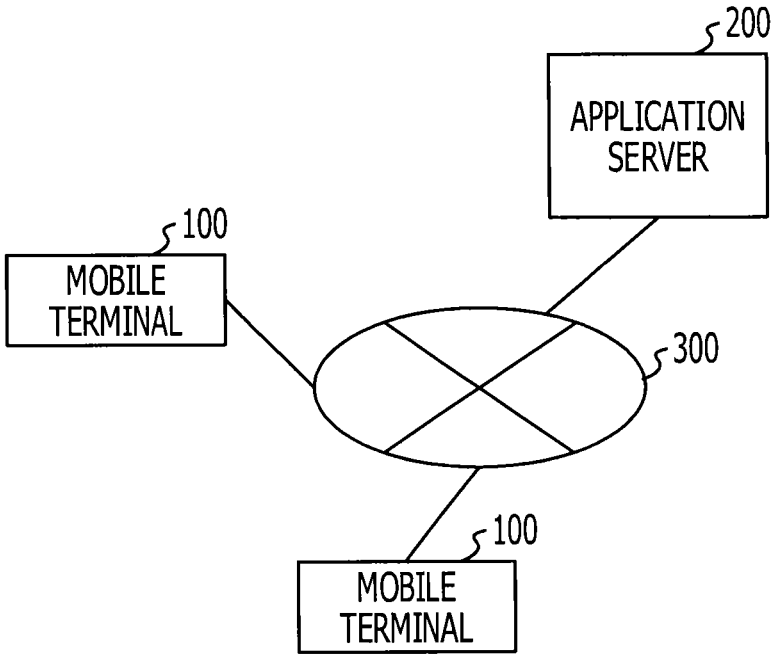

200
APPLICATION SERVER
100
MOBILE TERMINAL
300
100
MOBILE TERMINAL

FIG. 2

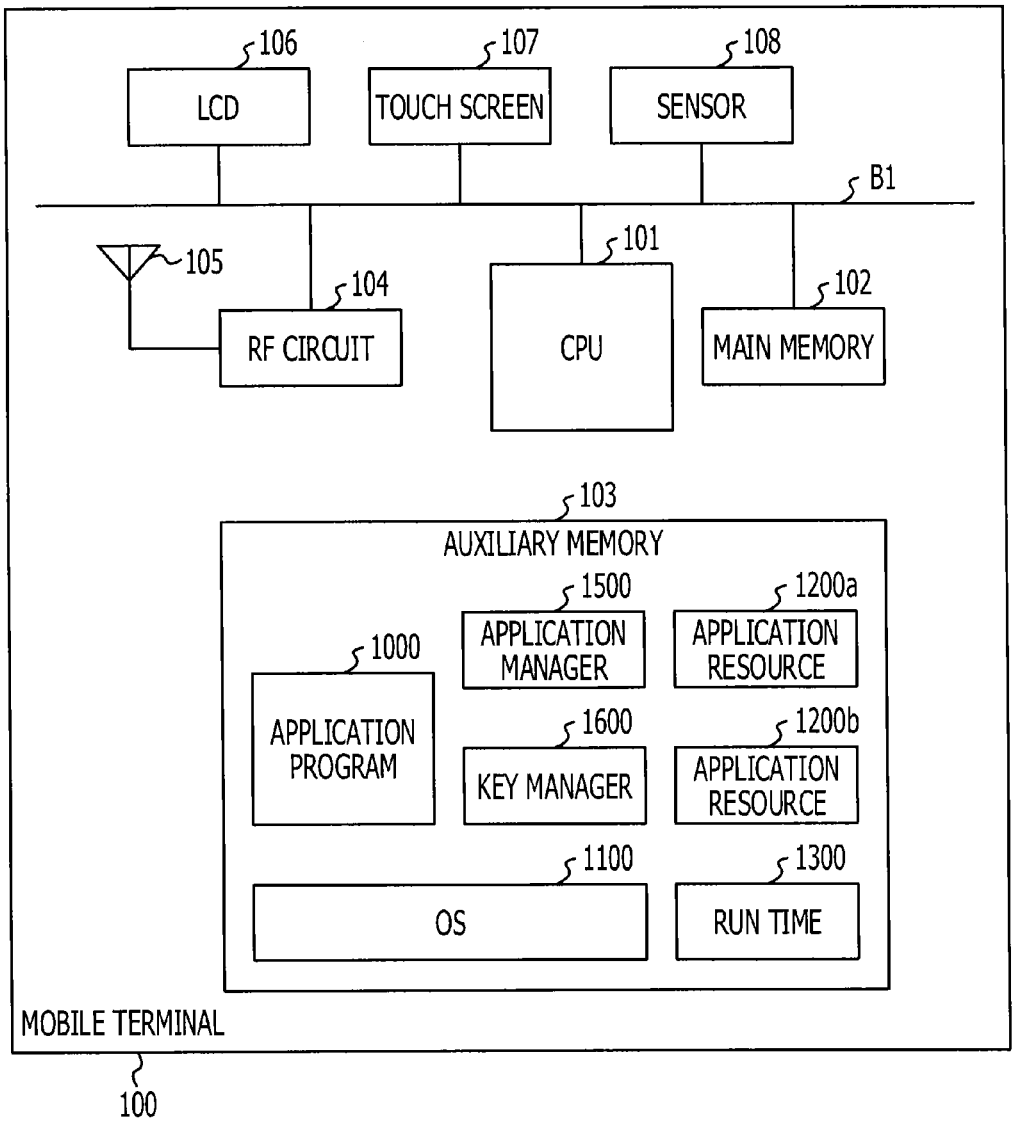

106
LCD
107
TOUCH SCREEN
108
SENSOR
B1
105
104
RF CIRCUIT
101
CPU
102
MAIN MEMORY
103
AUXILIARY MEMORY
1500
APPLICATION MANAGER
1200a
APPLICATION RESOURCE
1000
APPLICATION PROGRAM
1600
KEY MANAGER
1200b
APPLICATION RESOURCE
1100
OS
1300
RUN TIME
MOBILE TERMINAL
100

FIG. 3

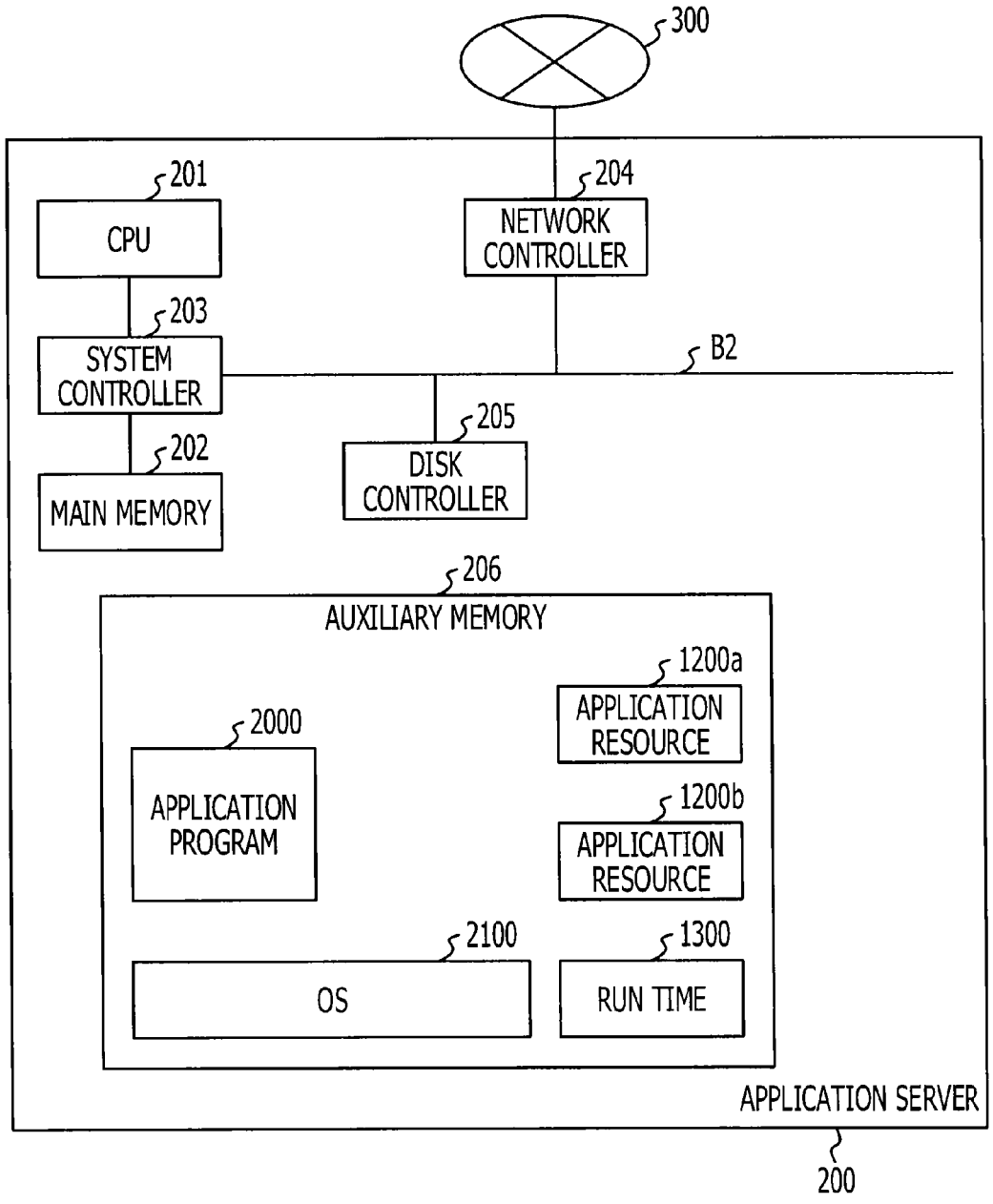

300
201
CPU
204
NETWORK CONTROLLER
203
SYSTEM CONTROLLER
B2
205
DISK CONTROLLER
202
MAIN MEMORY
206
AUXILIARY MEMORY
1200a
APPLICATION RESOURCE
2000
APPLICATION PROGRAM
1200b
APPLICATION RESOURCE
2100
OS
1300
RUN TIME
APPLICATION SERVER
200

FIG. 4A

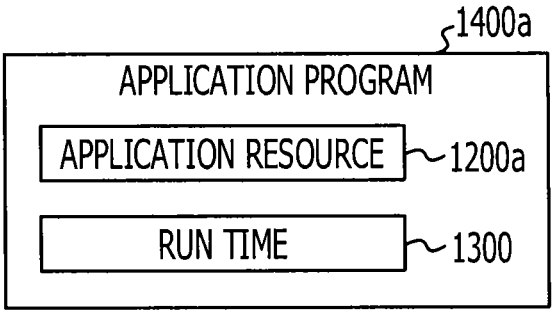

1400a
APPLICATION PROGRAM
APPLICATION RESOURCE
1200a
RUN TIME
1300

FIG. 4B

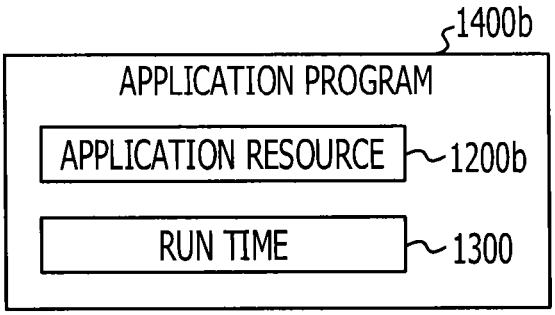

1400b
APPLICATION PROGRAM
APPLICATION RESOURCE
1200b
RUN TIME
1300

FIG. 5

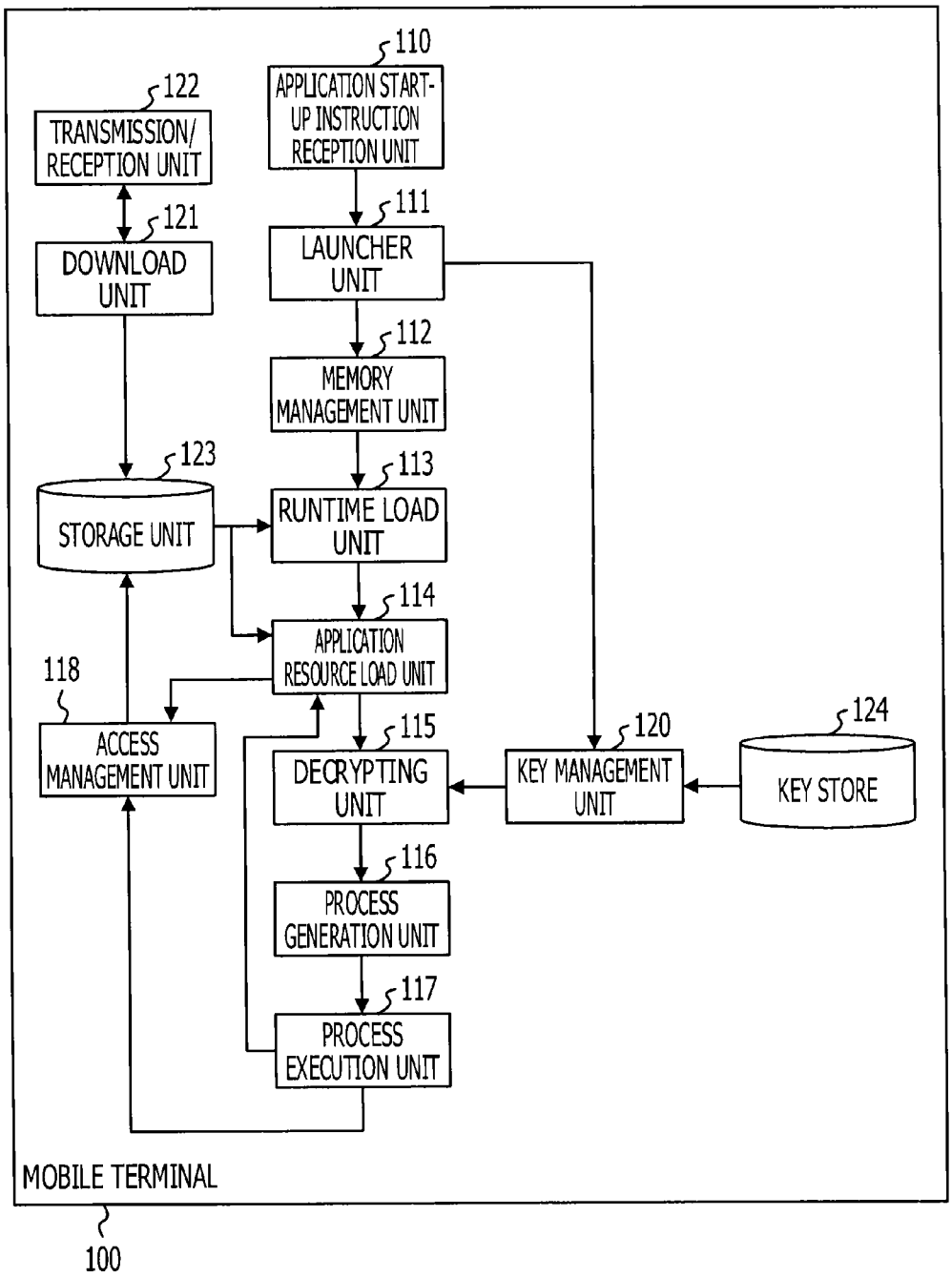

110
APPLICATION START-UP INSTRUCTION RECEPTION UNIT
122
TRANSMISSION/ RECEPTION UNIT
121
DOWNLOAD UNIT
111
LAUNCHER UNIT
112
MEMORY MANAGEMENT UNIT
123
STORAGE UNIT
113
RUNTIME LOAD UNIT
114
APPLICATION RESOURCE LOAD UNIT
118
ACCESS MANAGEMENT UNIT
115
DECRYPTING UNIT
120
KEY MANAGEMENT UNIT
124
KEY STORE
116
PROCESS GENERATION UNIT
117
PROCESS EXECUTION UNIT
MOBILE TERMINAL
100

FIG. 6

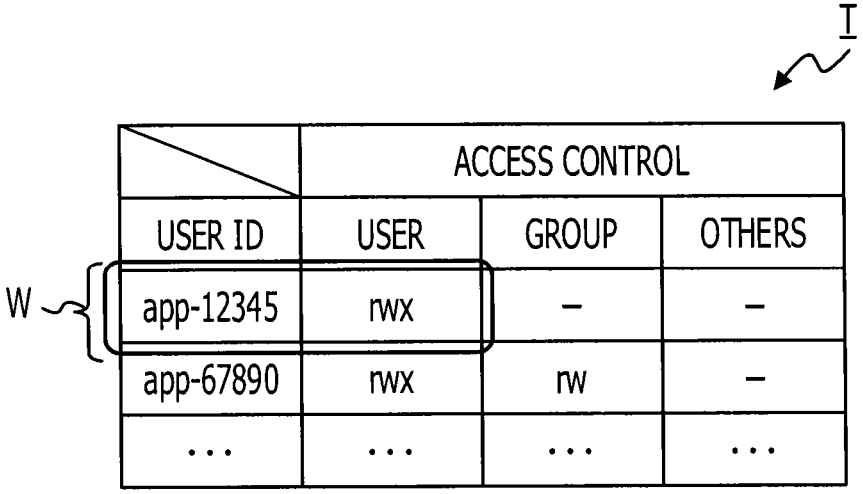

T
W
ACCESS CONTROL
USER ID
USER
GROUP
OTHERS
app-12345
rwx
–
–
app-67890
rwx
rw
–
...
...
...
...

FIG. 7

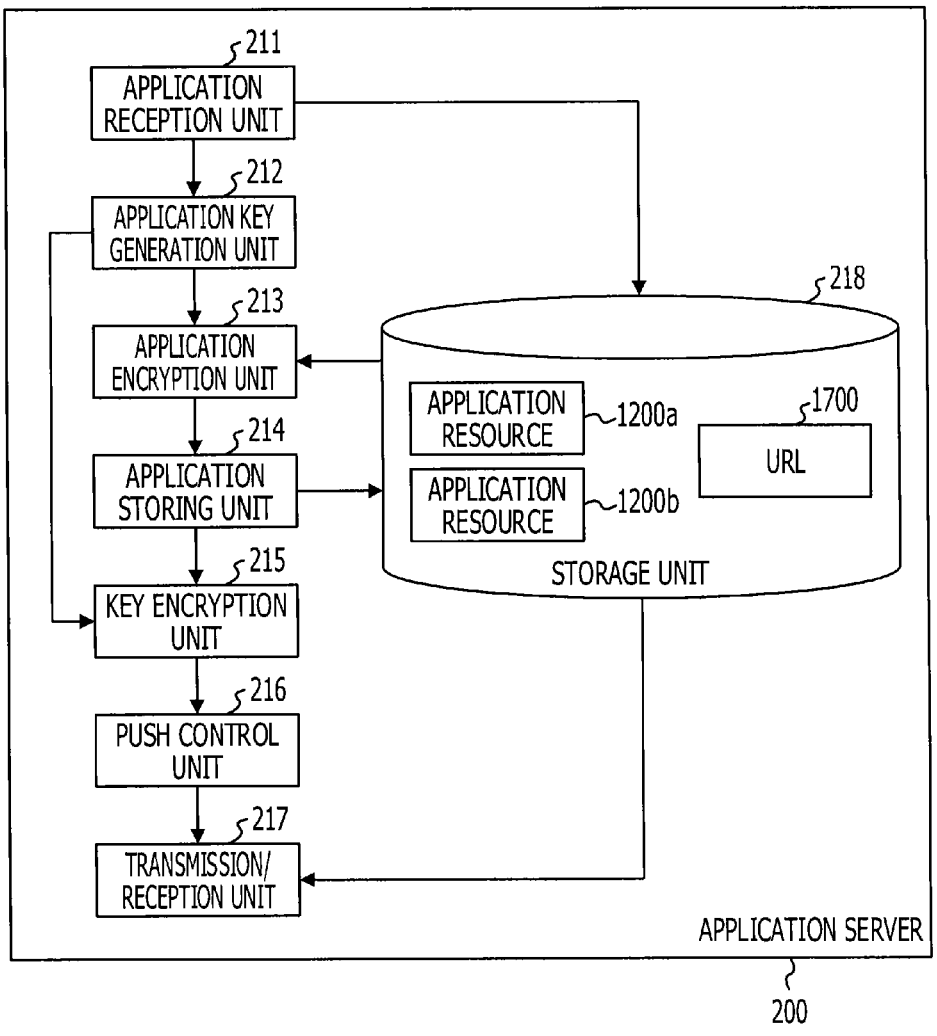

211
APPLICATION RECEPTION UNIT
212
APPLICATION KEY GENERATION UNIT
213
APPLICATION ENCRYPTION UNIT
214
APPLICATION STORING UNIT
215
KEY ENCRYPTION UNIT
216
PUSH CONTROL UNIT
217
TRANSMISSION/ RECEPTION UNIT
218
APPLICATION RESOURCE
1200a
APPLICATION RESOURCE
1200b
1700
URL
STORAGE UNIT
APPLICATION SERVER
200

FIG. 8

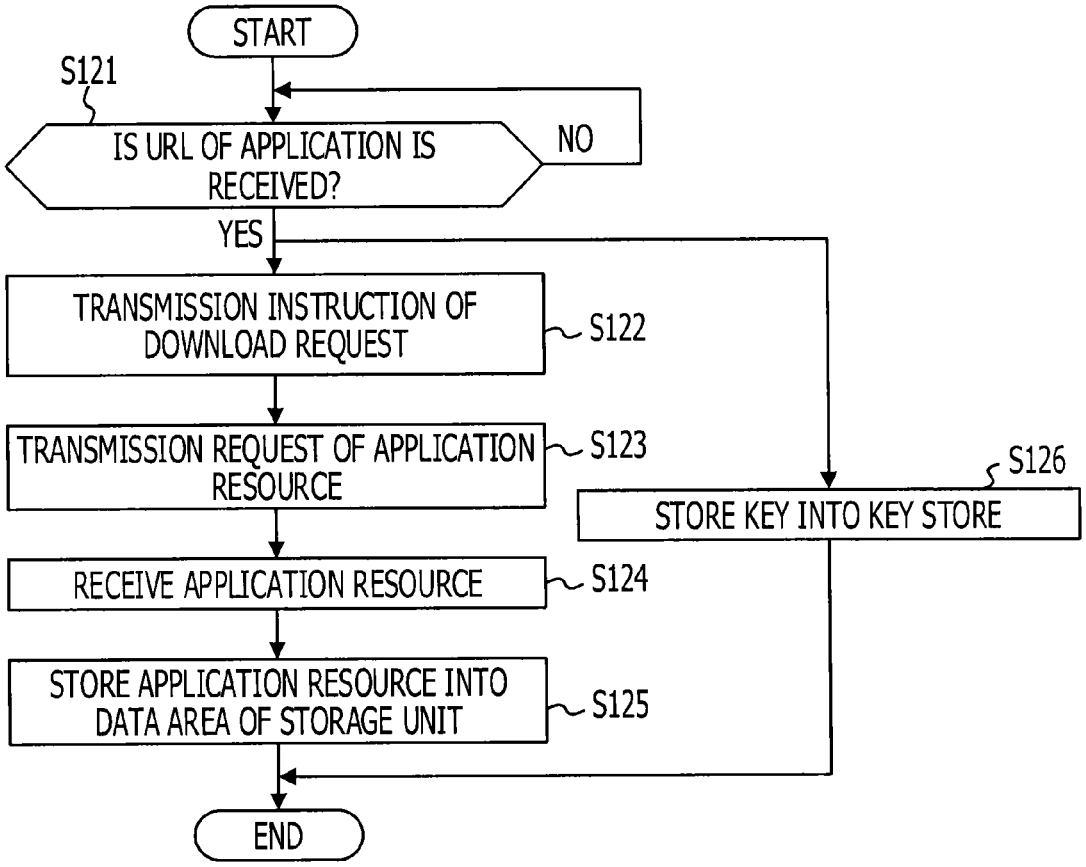

START
S121
IS URL OF APPLICATION IS RECEIVED?
NO
YES
TRANSMISSION INSTRUCTION OF DOWNLOAD REQUEST
S122
TRANSMISSION REQUEST OF APPLICATION RESOURCE
S123
RECEIVE APPLICATION RESOURCE
S124
STORE APPLICATION RESOURCE INTO DATA AREA OF STORAGE UNIT
S125
S126
STORE KEY INTO KEY STORE
END

FIG. 9

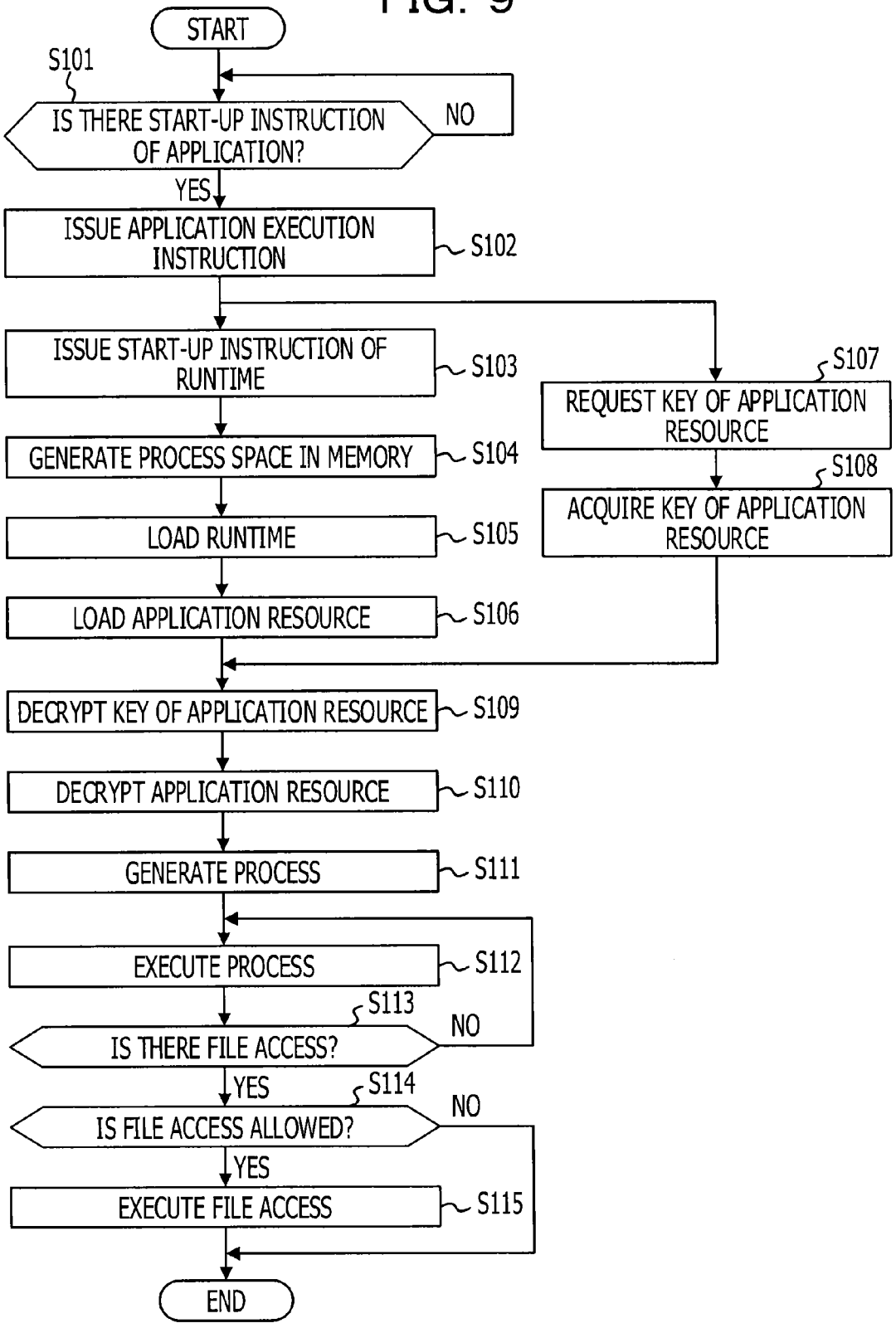

START
S101
IS THERE START-UP INSTRUCTION OF APPLICATION?
NO
YES
ISSUE APPLICATION EXECUTION INSTRUCTION
S102
ISSUE START-UP INSTRUCTION OF RUNTIME
S103
GENERATE PROCESS SPACE IN MEMORY
S104
LOAD RUNTIME
S105
LOAD APPLICATION RESOURCE
S106
S107
REQUEST KEY OF APPLICATION RESOURCE
S108
ACQUIRE KEY OF APPLICATION RESOURCE
DECRYPT KEY OF APPLICATION RESOURCE
S109
DECRYPT APPLICATION RESOURCE
S110
GENERATE PROCESS
S111
EXECUTE PROCESS
S112
S113
IS THERE FILE ACCESS?
NO
YES
S114
IS FILE ACCESS ALLOWED?
NO
YES
EXECUTE FILE ACCESS
S115
END

FIG. 10

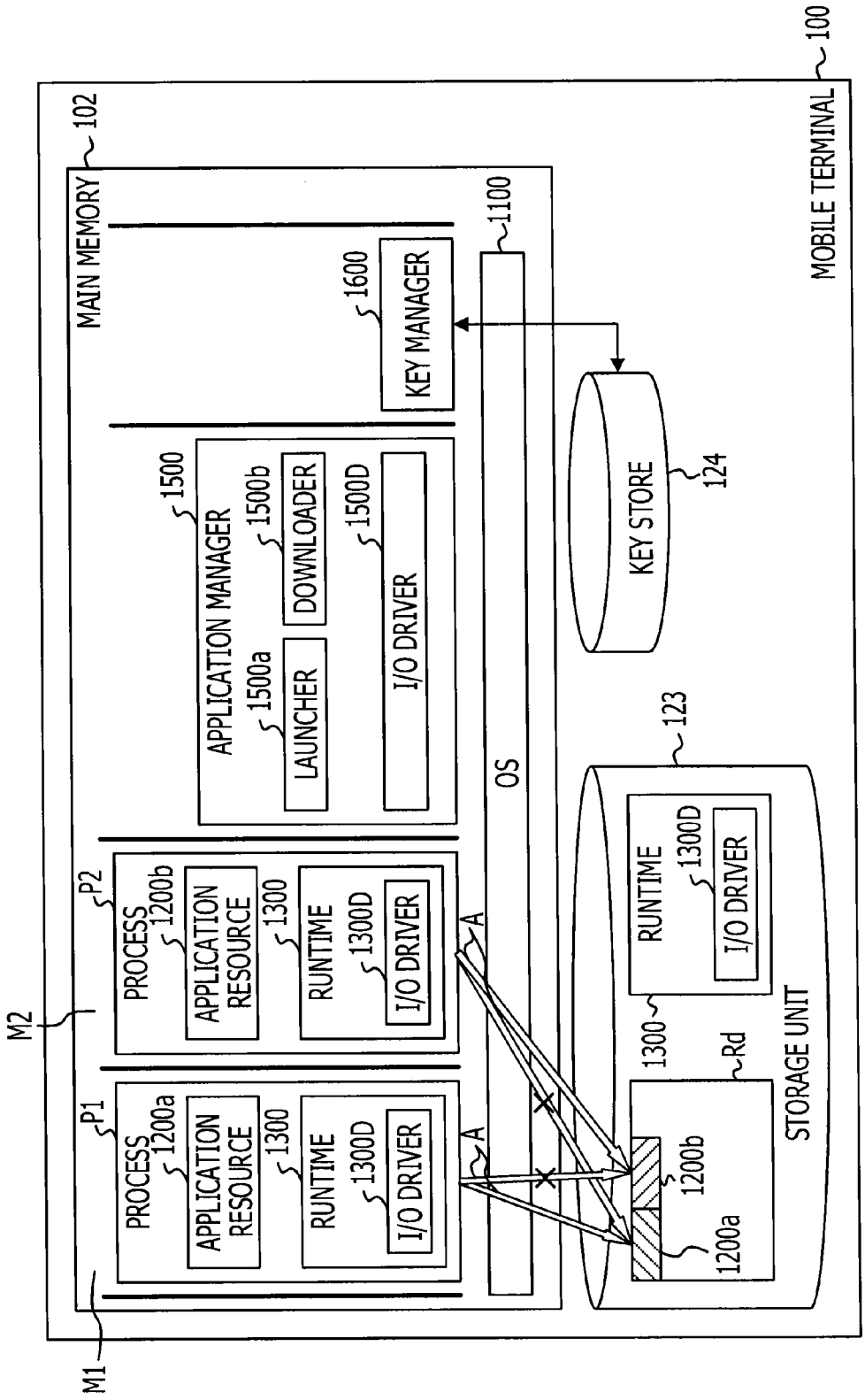

MOBILE TERMINAL
100
MAIN MEMORY
102
1600
KEY MANAGER
1100
OS
1500
APPLICATION MANAGER
1500a
LAUNCHER
1500b
DOWNLOADER
1500D
I/O DRIVER
KEY STORE
124
123
M2
P2
PROCESS
1200b
APPLICATION RESOURCE
1300
RUNTIME
1300D
I/O DRIVER
A
P1
PROCESS
1200a
APPLICATION RESOURCE
1300
RUNTIME
1300D
I/O DRIVER
A
1300
RUNTIME
1300D
I/O DRIVER
Rd
1200b
1200a
STORAGE UNIT
M1

FIG. 11

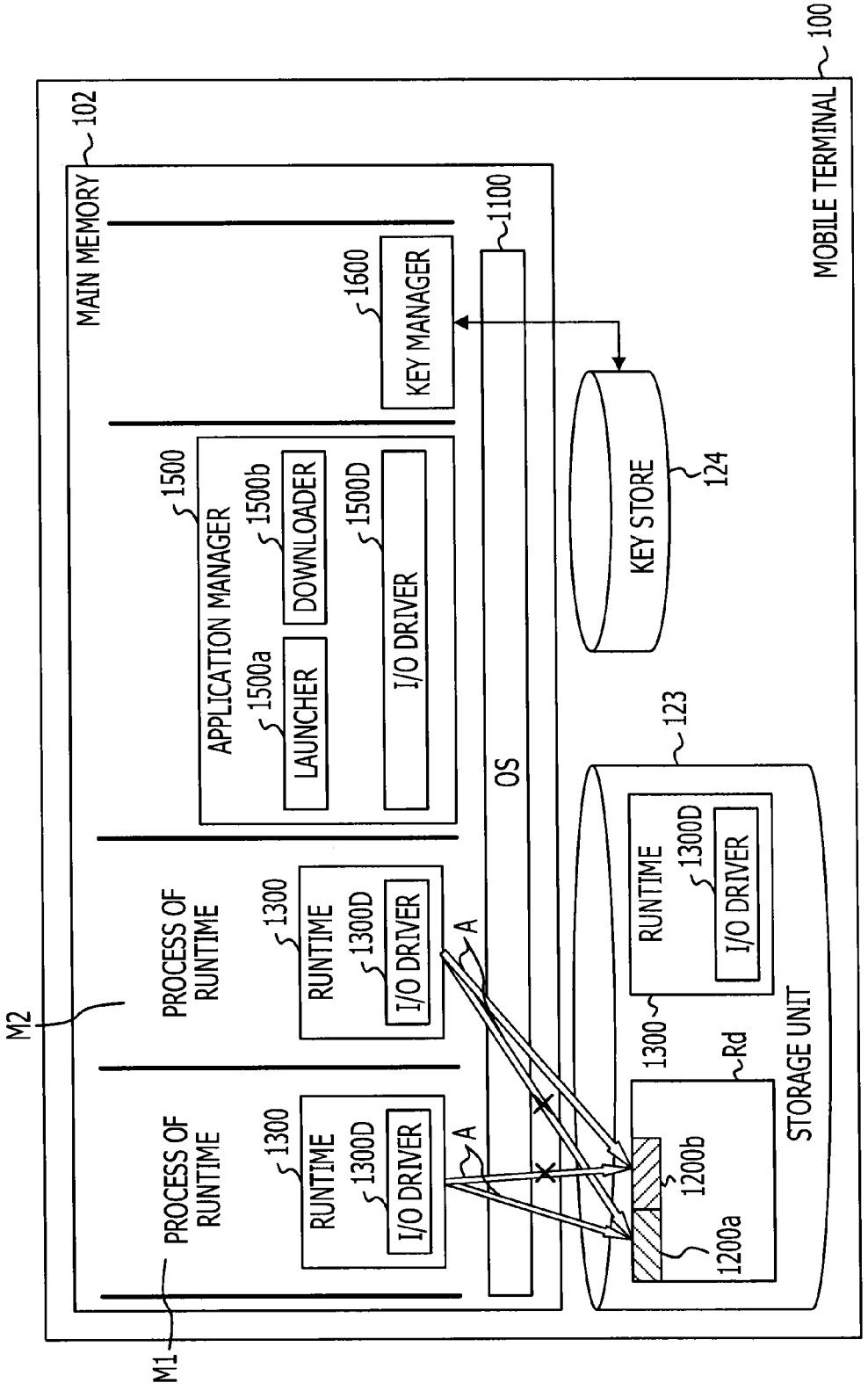
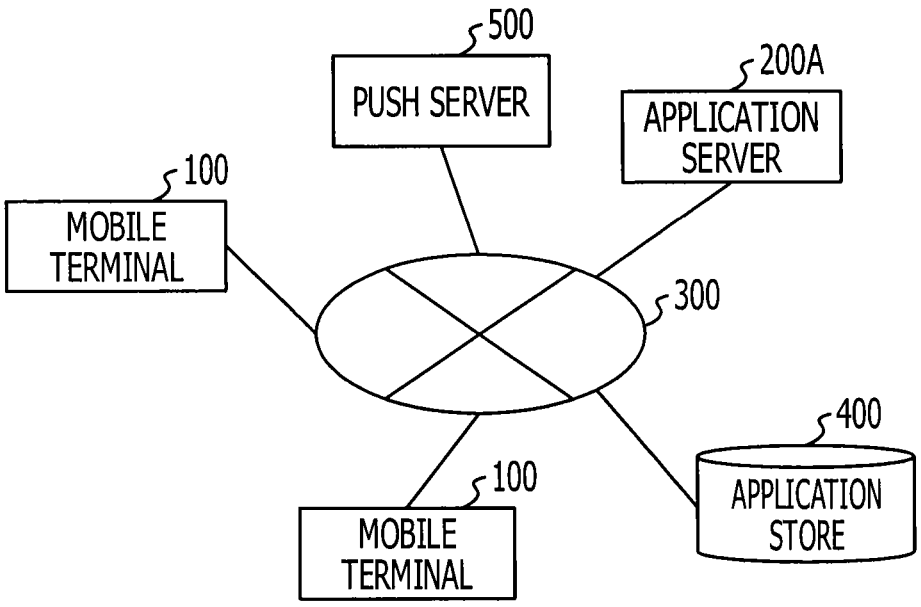

MOBILE TERMINAL
100
MAIN MEMORY
102
1100
OS
1600
KEY MANAGER
1500
APPLICATION MANAGER
1500a
LAUNCHER
1500b
DOWNLOADER
1500D
I/O DRIVER
KEY STORE
124
123
M2
PROCESS OF RUNTIME
1300
RUNTIME
1300D
I/O DRIVER
A
PROCESS OF RUNTIME
1300
RUNTIME
1300D
I/O DRIVER
A
1300
Rd
1200b
1200a
STORAGE UNIT
M1

FIG. 12


500
PUSH SERVER
200A
APPLICATION SERVER
100
MOBILE TERMINAL
300
400
APPLICATION STORE
100
MOBILE TERMINAL

INFORMATION PROCESSING APPARATUS AND INFORMATION PROCESSING METHOD

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2012-124554 filed on May 31, 2012, the entire contents of which are incorporated herein by reference.

FIELD

The embodiment discussed herein is related to an information processing apparatus, an information processing method, and a medium.

BACKGROUND

In recent years, with the widespread availability of wireless networks, such as 3G/LTE (Long Term Evolution) and hot spots develop, for example, an environment is provided in which an information processing apparatus such as a smartphone may be connected to a network at all times.

An information processing system is developed which delivers an application program from an application server (application store) to an information processing apparatus at a requested time and causes the information processing apparatus to execute the application program by utilizing such an environment. Also an information processing system is developed which provides an application program registered in an application server to an information processing apparatus according to a request from a user. In such systems, the application processing apparatus downloads an application program delivered from the application server and installs the application program in a storage device such as a flash memory.

Japanese Laid-open Patent Publication No. 2010-182309 is an example of related art.

SUMMARY

According to an aspect of the invention, an information processing apparatus that executes an application program including an application resource and a runtime, the information processing apparatus including a memory, and a processor that executes a procedure in the memory, the procedure including generating a process space in the memory to invoke the application program, loading the runtime into the process space, loading the application resource into the process space into which the runtime is loaded, generating a process of the application program based on the application resource and the runtime which are loaded into the process space, and executing the process of the application program.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic diagram of an information processing apparatus according to an embodiment;

FIG. **2** is a schematic diagram of a hardware configuration of a mobile terminal according to the embodiment;

FIG. **3** is a schematic diagram of a hardware configuration of an application server according to the embodiment;

FIGS. **4**A and **4**B are schematic diagrams of an application program according to the embodiment;

FIG. **5** is a schematic diagram of functional blocks of the mobile terminal according to the embodiment;

FIG. **6** is a schematic diagram of an access right table according to the embodiment;

FIG. **7** is a schematic diagram of functional blocks of the application server according to the embodiment;

FIG. **8** is a flowchart of downloading application resources by a CPU of the mobile terminal according to the embodiment;

FIG. **9** is a flowchart of executing an application by the CPU of the mobile terminal according to the embodiment;

FIG. **10** is a schematic diagram for explaining a restriction of access to a file stored in a storage unit according to the embodiment;

FIG. **11** is a schematic diagram for explaining a restriction of access to a file stored in the storage unit according to the embodiment; and

FIG. **12** is a schematic diagram of an information processing apparatus according to a modified example of the embodiment.

DESCRIPTION OF EMBODIMENTS

Hereinafter, an embodiment will be described with reference to the drawings.

While inventing the present embodiments, observations were made regarding a related art. Such observations include the following, for example.

In a related art, there are two types of application programs, which are an application program (called a native application) that may be directly interpreted and executed by an OS (operating system) and an application program (called a hybrid application) including a runtime that may be directly interpreted and executed by the OS and resources that may be interpreted by the runtime. The resource here is a program written in, for example, HTML or Javascript (registered trademark). An example of the hybrid application is a PhoneGap application. The resource in the hybrid application is independent from the OS, so that the hybrid application has an advantage that a developer may easily create application programs running on different OSes by replacing only a runtime which depends on the OS.

When delivering such a hybrid application to an information processing apparatus on which a specific OS is running, normally, a hybrid application, in which a runtime executable on the OS and resources are integrated and compiled to be converted into a native application format executable on the OS, is delivered.

However, when installing a plurality of hybrid applications that use the same runtime into an information processing apparatus, the same runtime is included in all the hybrid applications, so that a storage area is uselessly consumed. Some OSes require user's operation by display a confirmation screen when installing a native application. For example, in Android, when installing an application, a screen for determining whether or not to allow use of devices (GPS, acceleration sensor, and the like) that will be used by the application is displayed and the application may be installed only after the user presses a consent button. This is a useful security method to avoid installing a malicious application program. However, since this method requires a user operation,

there is a problem that usability degrades in a system in which many installation operations are performed. General hybrid applications are delivered in a form converted into the native application format, so that they have the same problem.

Therefore, when considering a system in which many hybrid applications are automatically installed and executed, there are a problem of inefficient consumption of storage area and a usability problem caused by an increase of user operations.

FIG. **1** is a schematic diagram of an information processing apparatus according to the embodiment.

As illustrated in FIG. **1**, the information processing apparatus according to the embodiment includes a mobile terminal **100** and an application server **200**. The mobile terminal **100** and the application server **200** are connected to each other through a network **300**. An application in the mobile terminal **100** is executed by runtime interpreting application resources. Hereinafter, the "application" is described as a function realized when a CPU **101** executes an application program.

Hardware Configuration of Mobile Terminal **100**

FIG. **2** is a schematic diagram of a hardware configuration of the mobile terminal **100** according to the embodiment.

In the embodiment, for example, a smartphone and a tablet PC (Personal Computer) are assumed to be the mobile terminal **100**.

As illustrated in FIG. **2**, the mobile terminal **100** according to the embodiment includes a CPU (Central Processing Unit) **101**, a main memory **102**, an auxiliary memory **103**, an RF (Radio Frequency) circuit **104**, an antenna **105**, an LCD (Liquid Crystal Display) **106**, a touch screen **107**, and various sensors **108**.

The CPU **101**, the main memory **102**, the auxiliary memory **103**, the RF circuit **104**, the LCD **106**, the touch screen **107**, and the various sensors **108** are connected to each other through, for example, a bus B**1**.

The CPU **101** controls various hardware in the mobile terminal **100**. Further, particular function is realized when the CPU **101** loads particular program stored in the auxiliary memory **103** into the main memory **102** and then executes the program in the main memory **102**. The details of each function will be described later.

The main memory **102** stores various programs to be executed by the CPU **101**. Further, the main memory **102** is used as a work area of the CPU **101** and stores various data used for the CPU **101** to execute processing. As the main memory **102**, for example, a RAM (Random Access Memory) may be used.

The auxiliary memory **103** stores various programs to be operated on the mobile terminal **100**. As the various programs, for example, an application program **1000**, an application manager **1500**, and a key manager **1600** which are executed by the CPU **101**, an OS **1100** which is an execution environment of these programs, and application resources **1200***a* and **1200***b* and a runtime **1300** which are downloaded from the application server **200** are stored. Further, the auxiliary memory **103** may store application programs downloaded from the application server **200** as the various programs.

Although the type of the OS **1100** is not particularly limited, Android (registered trademark) is used in the embodiment. The OS **1100** realizes a memory management unit **112**, a runtime load unit **113**, a process execution unit **117**, and an access management unit **118**, which will be described later, by being executed by the CPU **101**.

The runtime **1300** is a kind of native application that may be directly interpreted and executed by the OS **1100**. The runtime **1300** is compiled along with the application resources **1200***a* and **1200***b* so that a hybrid application is formed. The runtime **1300** performs an application resource load unit **114** and a process generation unit **116**, which will be described later, by being executed by the CPU **101**. Further, the runtime **1300** includes an I/O driver **1300**D. The I/O driver **1300**D realizes a decrypting unit **115** described later by being executed by the CPU **101**. Although, in the embodiment, the I/O driver **1300**D is included in the runtime **1300**, the embodiment is not limited to this.

The application manager **1500** includes a launcher **1500***a* and a downloader **1500***b* (not illustrated in FIG. **2**). The launcher **1500***a* performs an application start-up instruction reception unit **110** and a launcher unit **111**, which will be described later, by being executed by the CPU **101**. The downloader **1500***b* performs a download unit **121** described later by being executed by the CPU **101**. The key manager **1600** performs a key management unit **120** described later by being executed by the CPU **101**.

As the auxiliary memory **203**, for example, a non-volatile memory, such as a hard disk or a flash memory, may be used. The details of the application resources **1200***a* and **1200***b* and the runtime **1300** will be described later.

The RF circuit **104** is controlled by the CPU **101** and transmits a high frequency signal from the antenna **105** to another wireless communication apparatus. Further, the RF circuit **104** converts a high frequency signal received by the antenna **105** into a baseband signal and sends the baseband signal to the CPU **101**.

The LCD **106** is controlled by the CPU **101** and displays image information to a user. The touch screen **107** is attached to a display screen of the LCD **106** and detects a contact position at which, for example, a finger of a user comes into contact with the touch screen **107**. Touch screen **107** may be called a touch panel.

Each of the various sensors **108** is controlled by the CPU **101** and acquires state information of the mobile terminal **100**. As the sensors **108**, for example, an acceleration sensor, a gyro sensor, an illuminance sensor, a geomagnetic sensor, a tilt sensor, a pressure sensor, an approach sensor, a temperature sensor, a 3G, a wireless LAN, and a GPS module may be used.

Hardware Configuration of Application Server **200**

FIG. **3** is a schematic diagram of a hardware configuration of the application server **200** according to the embodiment.

As illustrated in FIG. **3**, the application server **200** according to the embodiment includes a CPU **201**, a main memory **202**, a system controller **203**, a network controller **204**, a disk controller **205**, and an auxiliary storage device **206**.

The CPU **201**, the main memory **202**, the system controller **203**, the network controller **204**, and the disk controller **205** are connected to each other through, for example, a bus B**2**.

The CPU **201** controls various hardware in the application server **200**. Further, particular function is realized when the CPU **201** loads particular program stored in the auxiliary memory **206** into the main memory **202** and then executes the program in the main memory **202**. The details of each function will be described later.

The main memory **202** stores various programs to be executed by the CPU **201**. Further, the main memory **202** is used as a work area of the CPU **201** and stores various data used for the CPU **201** to execute processing. As the main memory **202**, for example, a RAM may be used.

The system controller **203** is connected to both the CPU **201** and the main memory **202**. The system controller **203** controls data transmission between the CPU **201** and the main memory **202** and data transmission between the CPU **201** and

the bus B2. Further, the system controller **203** is connected to the network controller **204** and the disk controller **205** through the bus B2.

The network controller **204** is connected to the mobile terminal **100** through the network **300** and transmits and receives various data to and from the mobile terminal **100**.

The auxiliary storage device **206** is connected to the disk controller **205**. The auxiliary storage device **206** stores various programs. As the various programs, for example, an application program **2000** which is executed by the CPU **201**, an OS **2100** which is an execution environment of the application program **2000**, and the application resources **1200***a* and **1200***b* and the runtime **1300** which are to be downloaded to the mobile terminal **100** are stored. Not only the application resources **1200***a* and **1200***b* but also a native application to be downloaded to the mobile terminal **100** can be stored in the auxiliary storage device **206**. As the auxiliary storage device **206**, for example, a hard disk may be used.

Configurations of Application Programs **1400***a* and **1400***b*

Here, configurations of the application programs **1400***a* and **1400***b*, which are hybrid applications, will be described.

FIGS. **4**A and **4**B are schematic diagrams of the application programs **1400***a* and **1400***b* according to the embodiment. FIGS. **4**A and **4**B illustrate the application programs **1400***a* and **1400***b* for different applications from each other.

As illustrated in FIGS. **4**A and **4**B, the application programs **1400***a* and **1400***b* executed by the mobile terminal **100** are hybrid applications and include the application resources **1200***a* and **1200***b* which are created for each application and the runtime **1300** which is common to the applications.

The application resources **1200***a* and **1200***b* are, for example, program files developed by an application developer. The application resources **1200***a* and **1200***b* do not have an executable format that may be interpreted by the OS **1100**, so that the application resources **1200***a* and **1200***b* are recognized as data files by the OS **1100**. The application resources **1200***a* and **1200***b* are written in, for example, HTML or Java (registered trademark) script.

The runtime **1300** provides an execution environment to execute the application resources **1200***a* and **1200***b* as application programs to the mobile terminal **100**. The runtime **1300** is a kind of native application and has an executable format that may be interpreted by the OS **1100**, so that the runtime **1300** is recognized as an application program by the OS **1100**.

Functional Blocks of Mobile Terminal **100**

FIG. **5** is a schematic diagram of functional blocks of the mobile terminal **100** according to the embodiment.

As illustrated in FIG. **5**, the mobile terminal **100** according to the embodiment includes the application start-up instruction reception unit **110**, the launcher unit **111**, the memory management unit **112**, the runtime load unit **113**, the application resource load unit **114**, the decrypting unit **115**, the process generation unit **116**, the process execution unit **117**, the access management unit **118**, the key management unit **120**, the download unit **121**, a storage unit **123**, and a key store **124**.

Any of the application start-up instruction reception unit **110**, the launcher unit **111**, the memory management unit **112**, the runtime load unit **113**, the application resource load unit **114**, the decrypting unit **115**, the process generation unit **116**, the process execution unit **117**, the access management unit **118**, the key management unit **120**, the download unit **121**, the storage unit **123**, and the key store **124** are realized by the CPU **101** executing various programs read into the main memory **102**.

The application start-up instruction reception unit **110** receives an application start-up instruction from the application server **200** and notifies the launcher unit **111** of the application start-up instruction. The application start-up instruction specifies the application resource **1200***a* or **1200***b* and instructs start-up of the application resource **1200***a* or **1200***b*.

The launcher unit **111** issues a start-up instruction of the runtime **1300** with the specified application resource **1200***a* or **1200***b* as an argument on the basis of the application start-up instruction from the application start-up instruction reception unit **110**. Further, the runtime **111** requests a key to decrypt the specified application resource **1200***a* or **1200***b* from the key management unit **120**. However, start-up mechanism in the embodiment is not limited to this. For example, when a user taps an icon, the launcher unit **111** may issue a start-up instruction of the runtime **1300** with the application resource **1200***a* or **1200***b* corresponding to the icon as an argument.

The memory management unit **112** generates a process space to execute the specified application resource **1200***a* or **1200***b* in the main memory **102** on the basis of the start-up instruction of the runtime **1300**. The process space is a secure memory space that is separate for each process of a program executed by the CPU **101**.

The runtime load unit **113** loads the runtime **1300** stored in the storage unit **123** into the process space generated by the memory management unit **112**.

The application resource load unit **114** loads the specified application resource **1200***a* or **1200***b* into the process space into which the runtime **1300** is loaded on the basis of an instruction from the runtime load unit **113**. Further, the application resource load unit **114** may load a resource into the process space into which the runtime **1300** is loaded on the basis of an instruction from the process execution unit **117**.

The decrypting unit **115** decrypts a key transferred from the key management unit **120**. Further, the decrypting unit **115** operates as a part of the runtime **1300** and decrypts the application resource **1200***a* or **1200***b*, which is loaded into the process space, in the process space by using the decrypted key.

The process generation unit **116** generates a process of the application program **1400***a* or **1400***b* by integrating and compiling the application resource **1200***a* or **1200***b* and the runtime **1300** which are loaded into the process space.

The process execution unit **117** executes a process of the application program **1400***a* or **1400***b* generated in the process space. Further, the process execution unit **117** may instruct the application resource load unit **114** to load a resource used to execute the process while the process is being executed.

The access management unit **118** allows or restricts file access by the process execution unit **117** or the application resource load unit **114** on the basis of an access permission given in an access right table. The file access means one of reading, writing, or executing the application resource **1200***a* or **1200***b* and various application programs, which are stored in the storage unit **123**.

The key management unit **120** acquires a key to decrypt the application resource **1200***a* or **1200***b* from the key store **124** on the basis of the request from the launcher unit **111**. The key acquired from the key store **124** is stored in the key management unit **120**. Further, the key management unit **120** encrypts the key acquired from the key store **124** by using, for example, a key generated based on information unique to the mobile terminal **100** and transfers the encrypted key to the decrypting unit **115**. For example, a function of inter-process communication provided by the OS **1100** may be used to transfer the

key. In the embodiment, when Android is used as the OS **1100**, the Intent mechanism may be used for example.

The download unit **121** receives the application resource **1200***a* or **1200***b* transmitted from the application server **200** via a transmission/reception unit **122** and stores the application resource **1200***a* or **1200***b* in a data area Rd of the storage unit **123**. Further, the download unit **121** may receive a runtime and an application program as a native application stored in the application server **200** from the transmission/reception unit **122** in addition to the application resource **1200***a* or **1200***b* and store the runtime and the application program in the storage unit **123**. However, the runtime and the application program as a native application are stored in an application area different from the data area Rd of the storage unit **123**.

When a URL **1700** of the application resource **1200***a* or **1200***b* is transmitted from the application server **200**, the download unit **121** may instruct the transmission/reception unit **122** to transmit a transmission request of the application resource **1200***a* or **1200***b*.

The transmission/reception unit **122** receives an encrypted application resource **1200***a* transmitted from the application server **200**. When the URL **1700** of the application resource **1200***a* or **1200***b* is transmitted from the application server **200**, the transmission/reception unit **122** transmits the transmission request of the application resource **1200***a* or **1200***b* specified by the URL **1700** to the application server **200** on the basis of the instruction from the download unit **121**. When a token sent with the request, the transmission/reception unit **122** may transmit the transmission request including the token as additional information. That can prevent the mobile terminal which does not receive the request from getting the application.

For example, the storage unit **123** is constructed in the auxiliary memory **103** of the mobile terminal **100**. The storage unit **123** stores, for example, the application program **1000**, the OS **1100**, the application resources **1200***a* and **1200***b*, the runtime **1300**, and something like that. Further, an access permission provided by the OS **1100** is set to files stored in the storage unit **123**.

For example, the key store **124** is constructed in the auxiliary memory **103** of the mobile terminal **100**. The key store **124** stores a key to decrypt the application resource **1200***a* or **1200***b*. The keys stored in the key store **124** are desired to be protected more securely than the other data by using a hardware function or the like. For example, by using TRUSTZONE function included in some ARM processors, it may be possible to stop malicious software from taking out a key.

Although, in the embodiment, the key store **124** is constructed in the auxiliary memory **103**, the embodiment is not limited to this. For example, a memory chip is provided separately from the auxiliary memory **103** in which the application resource **1200***a* or **1200***b* is stored, and the key store **124** may be constructed in the memory chip.

Access Right Table T

Here, the access right set in the application program by the OS **1100** will be described.

FIG. **6** is a schematic diagram of the access right table T according to the embodiment.

As illustrated in FIG. **6**, the access right table T according to the embodiment associates a User ID of an application program with an access right to the application program (access control). In the embodiment, Android is used as the OS **1100**, so that a unique name associated with a name of an application ("Runtime", "App", and the like) is assigned to a User ID. For example, it is assumed that a name "app-12345" is assigned to "Runtime" and a name "appp-67890" is assigned to "App". In FIG. **6**, "r", "w", and "x" represent readable, writable, and executable respectively.

For example, when focusing on a field W in the access right table T, "r", "w", and "x" are assigned to an application program whose User ID is "app-12345", that is, the runtime **1300**, as an access right of User (owner). It means that a process of the runtime **1300** has permission to read, write, and execute data owned by the runtime **1300** stored in the storage unit **123**.

Functional Blocks of Application Server **200**

FIG. **7** is a schematic diagram of functional blocks of the application server **200** according to the embodiment.

As illustrated in FIG. **7**, the application server **200** according to the embodiment includes an application reception unit **211**, an application key generation unit **212**, an application encryption unit **213**, an application storing unit **214**, a key encryption unit **215**, a push control unit **216**, a transmission/reception unit **217**, and a storage unit **218**.

The application reception unit **211**, the application key generation unit **212**, the application encryption unit **213**, the application storing unit **214**, the key encryption unit **215**, the push control unit **216**, and the transmission/reception unit **217** are realized by the CPU **201** executing various programs load into the main memory **202**.

The application reception unit **211** receives registration of the application resources **1200***a* and **1200***b* developed by an application developer. The application reception unit **211** may receive registration of an application program as a native application in addition to the application resources.

The application key generation unit **212** generates a key to encrypt a specified application resource **1200***a* or **1200***b*. The key is generated based on the application resource **1200***a* or **1200***b* and information unique to the mobile terminal **100** of a transmission destination and is unique to each application and the mobile terminal **100** of a transmission destination. The method of encryption is not particularly limited.

The application encryption unit **213** encrypts the application resource **1200***a* or **1200***b* by using the key generated by the application key generation unit **212**.

The application storing unit **214** stores the application resource **1200***a* or **1200***b* encrypted by the application encryption unit **213** into the storage unit **218**.

The key encryption unit **215** encrypts the key to encrypt the application resource **1200***a* or **1200***b* by using a key generated based on information unique to the mobile terminal **100**.

The push control unit **216** instructs the transmission/reception unit **217** to transmit the application resource **1200***a* or **1200***b* or the URL **1700** of the application resource **1200***a* or **1200***b* and the key generated by the application key generation unit **212** on the basis of, for example, position information acquired from a sensor of the mobile terminal **100** and context information. Further, as auxiliary information, token information to acquire a specified application may be added.

The transmission/reception unit **217** transmits the URL **1700** or the application resource **1200***a* or **1200***b* stored in the storage unit **218** and the key to decrypt the URL **1700** or the application resource **1200***a* or **1200***b* to the mobile terminal **100** on the basis of the instruction from the push control unit **216**.

For example, the storage unit **218** is constructed in the auxiliary storage device **206** of the application server **200**. The storage unit **218** stores, for example, the application program **2000**, the OS **2100**, the application resources **1200***a* and **1200***b*, and the like. Further, the storage unit **218** may store the runtime **1300**.

Download of Application Resource by CPU **101** of Mobile Terminal **100**

FIG. **8** is a flowchart of downloading the application resource **1200***a* or **1200***b* by the CPU **101** of the mobile terminal **100** according to the embodiment.

As illustrated in FIG. **8**, the transmission/reception unit **122** determines whether or not the URL **1700** of the application transmitted from the application server **200** is received (step S**121**).

Here, if it is determined that the URL **1700** of the application is received (Yes in step S**121**), the download unit **121** instructs the transmission/reception unit **122** to transmit a download request for the application resource (here, the application resource **1200***a*) specified by the URL **1700** (step S**122**).

On the other hand, if it is determined that the URL **1700** of the application is not received (No in step S**121**), the transmission/reception unit **122** continues to determine whether or not the URL **1700** of the application is received (step S**121**).

The application server **200** transmits a key to decrypt the application resource **1200***a* along with the transmission of the URL **1700** of the application. The transmission/reception unit **122** transfers the key transmitted from the application server **200** to the key management unit **120**. Then, the key management unit **120** stores the key transferred from the transmission/reception unit **122** into the key store **124** (step S**126**). At this time, the key management unit **120** stores the key into the key store **124** after decrypting the key transferred from the application server **200** by using a key unique to the mobile terminal **100**.

Next, the transmission/reception unit **122** transmits a transmission request of the specified application resource **1200***a* to the application server **200** on the basis of the download request from the download unit **121** (step S**123**). When there is a token, the transmission/reception unit **122** may transmit the transmission request including the token as additional information. Thereby, the application server **200** transmits the specified application resource **1200***a* to the mobile terminal **100**.

The application resource **1200***a* transmitted from the application server **200** is encrypted by a key unique to the application resource **1200***a* and the mobile terminal **100**. Therefore, the transmission/reception unit **122** of the mobile terminal **100** receives the encrypted application resource **1200***a* (step S**124**). Then, the transmission/reception unit **122** transfers the application resource **1200***a* to the download unit **121**.

Next, the download unit **121** stores the application resource **1200***a* transferred from the transmission/reception unit **122** into the storage unit **123** (step S**125**). At this time, because the mobile terminal **100** recognizes the application resource **1200***a* as only a data file, the application resource **1200***a* is stored in the data area of the storage unit **123**.

An access permission whose User (owner) is the runtime **1300** is set to each data file at this time. Therefore, only a process of the runtime **1300** can access the data files stored in the data area Rd of the storage unit **123**. In other words, any process which the user Id is the runtime **1300** can access the data files stored in the data area Rd of the storage unit **123**.

Then, the download of the application resource **1200***a* is completed.

The download of the application resource is performed every time an execution instruction of an application is issued. Therefore, for example, when the application resource **1200***a* is downloaded and then further an execution instruction of another application (here, an application of the application resource **1200***b*) is issued, the application resource **1200***b* is stored in the storage unit **123** through the same procedure as described above. At this time, the application resource **1200***b* is recognized as only a data file, so that the application resource **1200***b* is stored in the data area Rd where the application resource **1200***a* is stored.

As described above, when the mobile terminal **100** according to the embodiment downloads a plurality of application resources **1200***a* and **1200***b* from the application server **200**, all the application resources **1200***a* and **1200***b* are stored in the common data area Rd as data files and the same access permission whose User (owner) is the runtime **1300** is set to each data file.

Here, the mobile terminal **100** transmits a download request to the application server **200** on the basis of the URL **1700** of the application transmitted from the application server **200**. However, the embodiment is not limited to this. For example, the application server **200** may transmit the application resource **1200***a* or **1200***b*, which is determined to be desirable by the application server **200**, to the mobile terminal **100** on the basis of information, such as position information acquired from a sensor of the mobile terminal **100** and context information. In other words, when the requested application resource **1200***a* or **1200***b* is transmitted to the mobile terminal **100** on the basis of the determination of the application server **200**, steps S**121** to S**124** described above are omitted.

Execution of Application by CPU **101** of Mobile Terminal **100**

FIG. **9** is a flowchart of executing an application by the CPU **101** of the mobile terminal **100** according to the embodiment. FIG. **10** is a schematic diagram for explaining a restriction of access to a file stored in the storage unit **123** according to the embodiment. FIG. **11** is a schematic diagram for explaining a restriction of access to a file stored in the storage unit **123** according to the embodiment.

In the description below, it is assumed that the application resources **1200***a* and **1200***b* and the runtime **1300** are stored in the storage unit **123** of the mobile terminal **100**.

As illustrated in FIG. **9**, first, the application start-up instruction reception unit **110** determines whether or not a start-up instruction of an application (here, application of the application resource **1200***a*) transmitted from the application server **200** is received (step S**101**). When the application resource **1200***a* is transmitted from the application server **200**, it may be determined that the start-up instruction of an application is received.

Here, if it is determined that the start-up instruction of an application is received (Yes in step S**101**), the application start-up instruction reception unit **110** issues an application execution instruction to the launcher unit **111** (step S**102**).

On the other hand, if it is determined that the start-up instruction of an application is not received (No in step S**101**), the application start-up instruction reception unit **110** continuously determines whether or not a start-up instruction of an application is received (step S**101**).

Next, the launcher unit **111** issues a start-up instruction of the runtime **1300** with a file name of the specified application resource **1200***a* as an argument on the basis of the application execution instruction from the application start-up instruction reception unit **110** (step S**103**).

Further, the launcher unit **111** requests a key to decrypt the specified application resource **1200***a* from the key management unit **120** (step S**107**).

Next, the memory management unit **112** generates a process space M**1** to execute the runtime **1300** and the application resource **1200***a* in the main memory **102** (step S**104**).

Next, the runtime load unit **113** loads the runtime **1300** stored in the storage unit **123** into the process space M**1**

generated by the memory management unit **112** (step S**105**). Thereby, a process of the runtime **1300** is generated in the process space M**1**.

Next, the application resource load unit **114** further loads the application resource **1200***a* into the process space M**1** into which the runtime **1300** is loaded (step S**106**).

In parallel with the above, the key management unit **120** acquires a key to decrypt the application resource **1200***a* from the key store **124** on the basis of the request from the launcher unit **111** (step S**108**). Further, the key management unit **120** encrypts the key acquired from the key store **124**. The encrypted key is transferred to the decrypting unit **115** by using a function of inter-process communication provided by the OS **1100**. The method of encryption is not particularly limited.

Next, the decrypting unit **115** decrypts the key transferred from the key management unit **120** (step S**109**) and decrypts the application resource **1200***a* loaded into the process space M**1** by using the decrypted key (step S**110**). In other words, the application resource **1200***a* is loaded into the process space M**1** and then decrypted (converted into a plain text).

Next, the process generation unit **116** generates a process P**1** of the application program **1400***a* in the process space M**1** by integrating and compiling the application resource **1200***a* decrypted by the decrypting unit **115** and the runtime **1300** (step S**111**).

The process P**1** is a process of the application program **1400***a*, which is a hybrid application including the application resource **1200***a* and the runtime **1300**. However, the OS **1100** recognizes the application resource **1200***a* as only data, so that the OS **1100** recognizes the process P**1** as a process of the runtime **1300**.

Next, the process execution unit **117** executes the process P**1** of the application program **1400***a* (step S**112**).

Next, the access management unit **118** determines whether or not the process P**1** executed by the process execution unit **117** requires an access to a file stored in the storage unit **123** (step S**113**).

Here, if it is determined that the process P**1** requires an access to an application resource (for example, icon image) (Yes in step S**113**), the access management unit **118** refers to an access permission in the access right table T and determines whether the access is valid or not (step S**114**).

On the other hand, if it is determined that the process P**1** does not requires an access to an application resource (No in step S**113**), the process execution unit **117** continuously executes the process P**1** of the application program **1400***a* (step S**112**).

When it is determined that the process P**1** requires an access to an application resource (Yes in step S**113**) and the process P**1** is allowed to access the application resource (Yes in step S**114**), the process execution unit **117** accesses the application resource, such as reading, writing, or executing the application resource stored in the storage unit **123** (step S**115**).

The mobile terminal **100** according to the embodiment performs the series of processes described above for each execution of an application. Therefore, for example, when another application (here, the application of the application resource **1200***b*) is executed after the process P**1** of the application program **1400***a* is generated, a process P**2** of the application program **1400***b* is generated. Furthermore, both the processes P**1** and P**2** of the application programs **1400***a* and **1400***b* are recognized as a process of the runtime **1300**.

Therefore, as indicated by arrows A in FIG. **10**, the process P**1** and the process P**2** are allowed to access both the application resources **1200***a* and **1200***b* stored in the data area Rd of the storage unit **123**. If this is left unattended, for example, when the process P**1** is a malicious process, the process P**1** may make an unauthorized access to the application resource **1200***b* stored in the storage unit **123** and tamper the application resource **1200***b*.

Therefore, in the embodiment, the application resources **1200***a* and **1200***b* stored in the data area Rd of the storage unit **123** are individually encrypted by using a different key for each application resource. Further, the process P**1** has only a key to decrypt the application resource **1200***a* of the process P**1** and the process P**2** has only a key to decrypt the application resource **1200***b* of the process P**2**.

Therefore, the process P**1** may possibly not perform reading, writing, or executing the application resource **1200***b* stored in data area Rd of the storage unit **123**. Similarly, the process P**2** may not perform reading, writing, or executing the application resource **1200***a* stored in data area Rd of the storage unit **123**.

Thereby, even if an application resource downloaded to the mobile terminal **100** performs a malicious operation in the mobile terminal **100**, it is possible to protect the application resources **1200***a* and **1200***b* stored in the data area Rd of the storage unit **123** from, for example, a threat of unauthorized access.

Further, the application resource load unit **114** executes loading the application resource **1200***a* or **1200***b* as a process of the runtime **1300**. Therefore, as indicated by arrows B in FIG. **11**, processes of the runtime **1300** are allowed to access both the application resources **1200***a* and **1200***b* stored in the data area Rd of the storage unit **123**.

However, in the embodiment, as described above, the application resources **1200***a* and **1200***b* stored in the data area Rd of the storage unit **123** are individually encrypted by one of keys different from each other. Further, a process of the runtime **1300** has only a key to decrypt a specified application resource **1200***a* or **1200***b*.

Therefore, a process of the runtime **1300** started with the application resource **1200***a* as an argument may not read the application resource **1200***b* stored in the data area Rd of the storage unit **123**. Similarly, a process of the runtime **1300** started with the application resource **1200***b* as an argument may not read the application resource **1200***a* stored in the data area Rd of the storage unit **123**.

Thereby, when the mobile terminal **100** tries to execute the application program **1400***a*, the process of the runtime **1300** does not read the application resource **1200***b* stored in the data area Rd of the storage unit **123**. On the other hand, when the mobile terminal **100** tries to execute the application program **1400***b*, the process of the runtime **1300** does not read the application resource **1200***a* stored in the data area Rd of the storage unit **123**. As a result, the mobile terminal **100** according to the embodiment may reliably execute the specified application.

According to the embodiment, the process P**1** or P**2** of the application program **1400***a* or **1400***b* is generated by downloading the application resource **1200***a* or **1200***b* from the application server **200** and executing the process P**1** or P**2** of the application program **1400***a* or **1400***b* on the runtime **1300** pre-installed in the mobile terminal **100**.

Therefore, it is possible to reduce the amount of data downloaded from the application server **200** by the amount of data of the runtime **1300**. Further, the mobile terminal **100** does not recognize the application resources **1200***a* and **1200***b* as an application program, so that when the application resource **1200***a* or **1200***b* is downloaded, no confirmation display (consent button or the like) is generated for a user of the mobile terminal **100**. Therefore, it is possible to realize reduction of

cumbersome feeling of the user of the mobile terminal **100** and reduction of inefficient consumption of the storage area of the mobile terminal **100**.

Further, according to the embodiment, every time the application resources **1200***a* and **1200***b* are executed, the process spaces M**1** and M**2** separated from each other are generated and a set of the runtime **1300** and the application resource **1200***a* and a set of the runtime **1300** and the application resource **1200***b* are loaded into the process spaces M**1** and M**2** respectively. In other words, a plurality of application resources **1200***a* and **1200***b* are not loaded into the process space M**1** or M**2**. Therefore, a plurality of application resources **1200***a* and **1200***b* do not interfere with each other in the process space M**1** or M**2**.

According to the embodiment, the application resources **1200***a* and **1200***b* stored in the data area Rd of the storage unit **123** are individually encrypted by one of keys different from each other. Further, the process P**1** is given only a key to decrypt the application resource **1200***a* of the process P**1** and the process P**2** is given only a key to decrypt the application resource **1200***b* of the process P**2**. Therefore, the processes P**1** and P**2** can only access their own application resources in the application resources stored in the data area Rd of the storage unit **123**. Thereby, it is possible to protect the application resources **1200***a* and **1200***b* stored in the storage unit **123** of the mobile terminal **100** from, for example, a risk of unauthorized access due to a malicious application resource.

Further, it is possible to obtain the function described above by only adding the application resource load unit **114**, the decrypting unit **115**, and the process generation unit **116**, which are performed by the runtime **1300**, the launcher unit **111** and the download unit **121** which are performed by the application manager **1500**, and the key management unit **120** which is performed by the key manager **1600** (in other words, by still using the existing OS **1100**).

MODIFIED EXAMPLE

FIG. **12** is a schematic diagram of an information processing apparatus according to a modified example of the embodiment.

Although, in the embodiment described above, the application server **200** includes a function to store the application resource and a function to push the application resource, the embodiment is not limited to this.

For example, as illustrated in FIG. **12**, it is possible to use an application server **200**A which does not include the function to store the application resource and the function to push the application resource. In this case, an application store **400** including the storage unit **218** that stores the application resource and a push server **500** including the push control unit **216** that controls push of the application resource are provided separately and the application store **400** and the push server **500** may be connected to each other through the network **300**.

All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiment of the present invention has been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. An information processing apparatus that executes application programs, the information processing apparatus comprising:

a memory; and

a processor coupled to the memory and configured to:

generate a first process space in the memory to invoke a first application program of the application programs,

generate a second process space to invoke a second application program, the second process space being separate from the first process space,

load a runtime for the application programs into the first process space,

load a first application resource for executing the first application program into the first process space,

generate a first process of the first application program based on the first application resource and the runtime which are loaded into the first process space,

execute the first process of the first application program in the first process space separately from the second process space,

load the runtime into the second process space,

load a second application resource for executing the second application program into the second process space,

generate a second process of the second application program based on the second application resource and the runtime which are loaded into the second process space, and

execute the second process of the second application program in the second process space separately from the first process space, wherein

the first and second application programs are hybrid application programs, and

the runtime is a native application program which enables an application source to be executed as one of the application programs.

2. The information processing apparatus according to claim **1**, wherein

the first application resource to be loaded into the first process space is encrypted in a storage,

the second application resource to be loaded into the second process space is encrypted in a storage, and

the processor is further configured to:

manage a first key to decrypt the encrypted first application resource,

manage a second key to decrypt the encrypted second application resource,

decrypt the encrypted first application resource loaded into the first process space by the first key, and

decrypt the encrypted second application resource loaded into the second process space by the second key.

3. The information processing apparatus according to claim **2**, wherein the processor is further configured to:

encrypt the first key and the second key,

decrypt the encrypted first key and the encrypted second key,

decrypt the first application resource loaded into the first process space by the decrypted first key, and

decrypt the second application resource loaded into the second process space by the decrypted second key.

4. The information processing apparatus according to claim **3**, wherein

the processor is further configured to:

request the first key based on a start-up instruction of the first application program, and

request the second key based on a start-up instruction of the second application program.

5. The information processing apparatus according to claim 2, wherein

the memory stores a plurality of application resources encrypted by different keys each of which is used for one of the application programs.

6. The information processing apparatus of claim 1, wherein

the first application resource and the second application resource are stored in the information processing apparatus separately from the runtime.

7. The information processing apparatus of claim 1, wherein

the first application resource to be loaded into the first process space is encrypted in a storage.

8. The information processing apparatus of claim 7, wherein the processor is configured to:

load the encrypted first application resource from the storage into the first process space, and

provide only the first process with a first key to decrypt the encrypted first application resource which is loaded into the first process space.

9. The information processing apparatus of claim 8, wherein

the processor is further configured not to provide the second process with the key.

10. The information processing apparatus of claim 8, wherein

the second application resource to be loaded into the second process space is encrypted in the storage, and

the processor is further configured to:

load the encrypted second application resource from the storage into the second process space, and

provide only the second process with a second key to decrypt the decrypted second application resource which is loaded into the second process space.

11. The information processing apparatus of claim 8, wherein the processor is further configured to:

encrypt the first key to be provided only the first process, and

decrypt the encrypted first key when decrypting the encrypted first application resource which is loaded into the first process space.

12. The information processing apparatus of claim 1, wherein

the first application resource includes a first program for executing the first application program, a first image being accessed when the first application program is executed, or a combination thereof.

13. The information processing apparatus of claim 12, wherein the first program is based on one of Hyper Text Markup Language and JavaScript.

14. The information processing apparatus of claim 12, wherein the first image is an icon image for the first application program.

15. The information processing apparatus of claim 1, wherein the first application resource has been developed in a specific application development environment on a premise of the runtime that is configured to decrypt an encrypted application resource.

16. The information processing apparatus of claim 1, wherein the first application resource is distributed to the information processing apparatus separately from the runtime.

17. The information processing apparatus of claim 1, wherein

the first and second application programs are hybrid application programs, and

the runtime is a native application program which enables an application source to be executed as one of the application programs.

18. An information processing method of an information processing apparatus that executes application programs, the information processing method comprising:

generating a first process space in a memory to invoke a first application program of the application programs,

generating a second process space to invoke a second application program, the second process space being separate from the first process space;

loading a runtime for the application programs into the first process space;

loading a first application resource for executing the first application program into the first process space;

generating a first process of the first application program based on the first application resource and the runtime which are loaded into the first process space;

executing the first process of the first application program in the first process space separately from the second process space;

loading the runtime into the second process space,

loading a second application resource for executing the second application program into the second process space,

generating a second process of the second application program based on the second application resource and the runtime which are loaded into the second process space, and

executing the second process of the second application program in the second process space separately from the first process space, wherein

the first and second application programs are hybrid application programs, and

the runtime is a native application program which enables an application source to be executed as one of the application programs.

19. The information processing method according to claim 18, wherein

the loading the first application resource includes loading an encrypted first application resource into the first process space, the encrypted first application resource being encrypted by a first key,

the loading the second application resource includes loading an encrypted second application resource into the second process space, the encrypted second application resource being encrypted by a second key, and

the information processing method further includes:

decrypting the encrypted first application resource loaded into the first process space by the first key, and

decrypting the encrypted second application resource loaded into the second process space by the second key.

20. A non-transitory medium for storing a program of an information processing apparatus that executes application programs, the program causing the information processing apparatus to execute a process, the process comprising:

generating a first process space in a memory to invoke a first application program of the application programs,

generating a second process space to invoke a second application program, the second process space being separate from the first process space;

loading a runtime for the application programs into the first process space;

loading a first application resource for executing the first application program into the first process space;

generating a first process of the first application program on the basis of the first application resource and the runtime which are loaded into the first process space;

executing the first process of the first application program in the first process space separately from the second process space,

loading the runtime into the second process space,

loading a second application resource for executing the second application program into the second process space,

generating a second process of the second application program based on the second application resource and the runtime which are loaded into the second process space, and

executing the second process of the second application program in the second process space separately from the first process space, wherein

the first and second application programs are hybrid application programs, and

the runtime is a native application program which enables an application source to be executed as one of the application programs.

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